Integrated Tests and Evaluations

Presented by: CJ Bixby
Project Systems Engineering Lead

Compiled by: Jim Murphy and Sam Kim
Integrated Tests and Evaluations Co-Leads

Meeting of Experts on NASA's Unmanned Aircraft System (UAS) Integration in the National Airspace Systems (NAS) Project

Aeronautics and Space Engineering Board
National Research Council
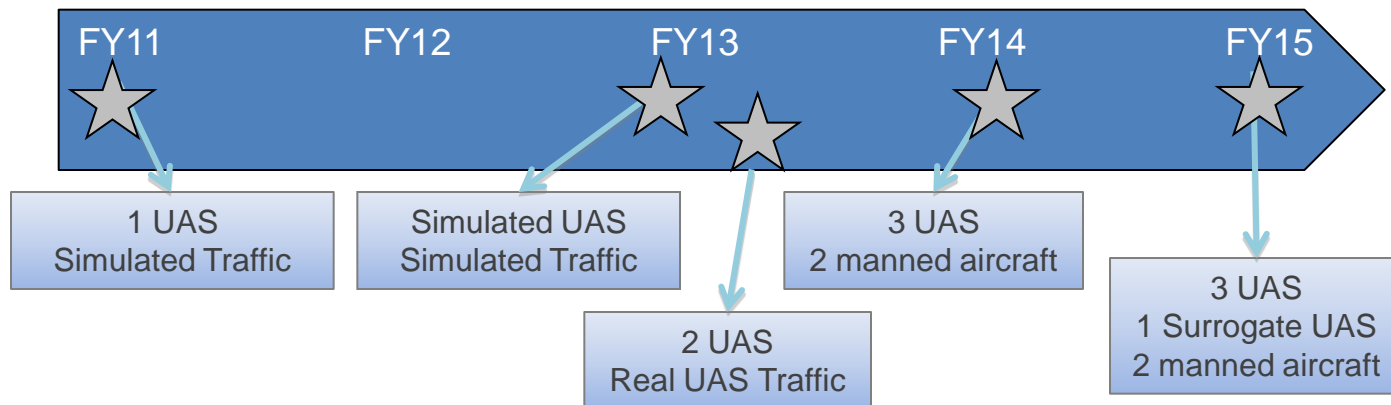August 5, 2010

Integrated Tests and Evaluations

- Simulations and flight demonstrations cut across technical areas
- Represent the culmination of many focused tests conducted by each subelement.
- Provide complex and relevant environments in which to evaluate and validate the work of the subelements

Provide systems-level, integrated concepts that address barriers to routine access to the NAS. Through simulation and flight testing, address issues including separation assurance, communications requirements, and human factors issues in operationally relevant environments.
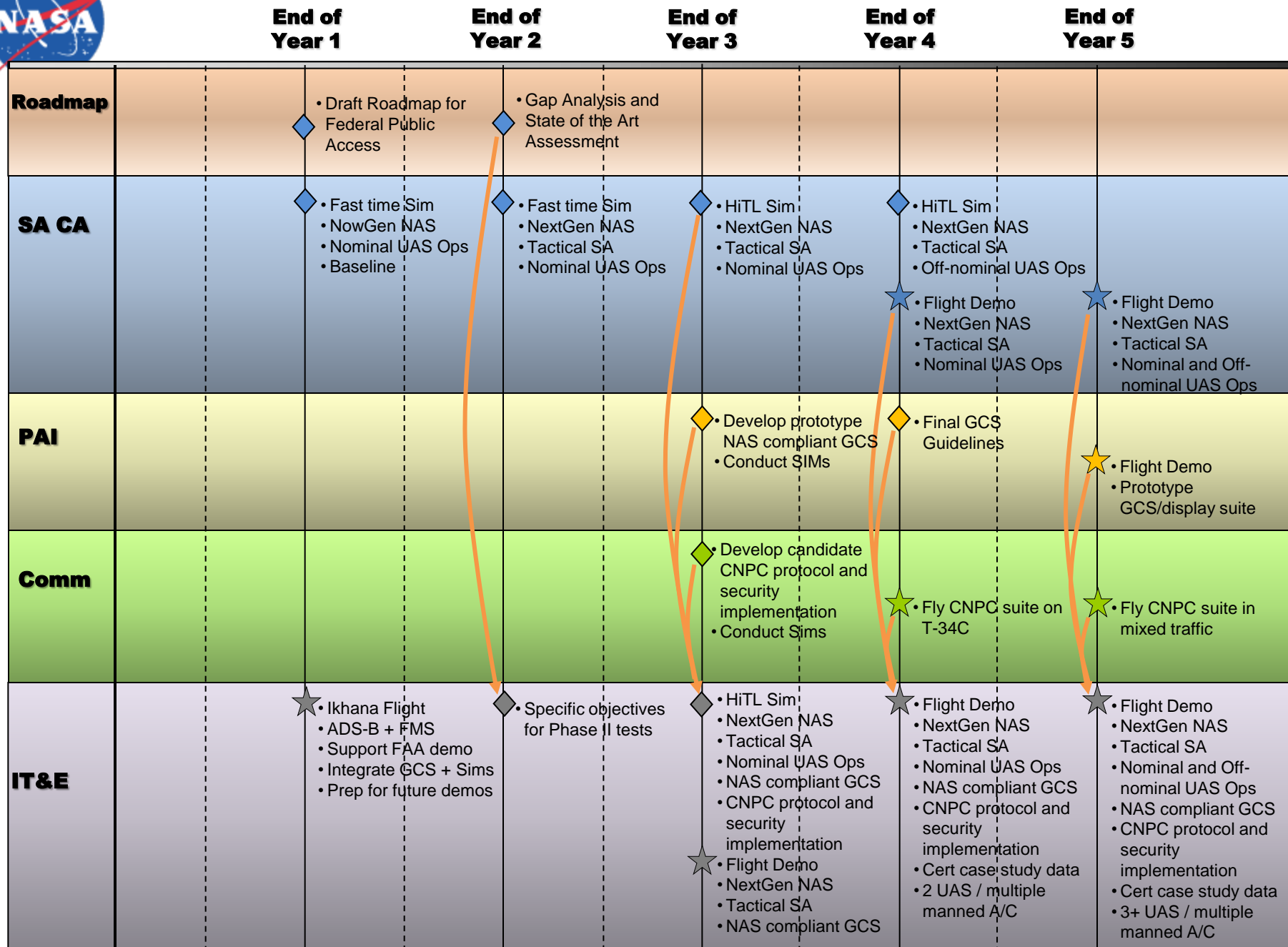
Integrated Tests and Evaluations Approach

- Use phase I to do detailed test planning for phase II
- Assist subelements with test planning
  - Assist with documenting test objectives, data and facilities/infrastructure requirements, and detailed test planning
  - Provide facilities/infrastructure to meet test requirements
  - Provide interfaces between tools
  - Develop, document, and execute data handling and dissemination plans
  - Provide a test engineer to facilitate scheduling of facilities, support specific equipment and software needs, track schedule progress, and monitor changes to schedule
  - Provide guidance for alternative facilities or equipment to mitigate risk associated with loss of availability
- Provide opportunities for subelements to gather data in relevant and increasingly complex environments

| FY11 | FY12 | FY13 | FY14 | FY15 |

1 UAS
Simulated Traffic

Simulated UAS
Simulated Traffic

3 UAS
2 manned aircraft

2 UAS
Real UAS Traffic

3 UAS
1 Surrogate UAS
2 manned aircraft

UAS Integration in the NAS IT&E Milestones

	End of Year 1	End of Year 2	End of Year 3	End of Year 4	End of Year 5
Roadmap	• Draft Roadmap for Federal Public Access	• Gap Analysis and State of the Art Assessment			
SA CA	• Fast time Sim • NowGen NAS • Nominal UAS Ops • Baseline	• Fast time Sim • NextGen NAS • Tactical SA • Nominal UAS Ops	• HiTL Sim • NextGen NAS • Tactical SA • Nominal UAS Ops	• HiTL Sim • NextGen NAS • Tactical SA • Off-nominal UAS Ops • Flight Demo • NextGen NAS • Tactical SA • Nominal UAS Ops	• Flight Demo • NextGen NAS • Tactical SA • Nominal and Off-nominal UAS Ops
PAI			• Develop prototype NAS compliant GCS • Conduct SIMs	• Final GCS Guidelines	• Flight Demo • Prototype GCS/display suite
Comm			• Develop candidate CNPC protocol and security implementation • Conduct Sims	• Fly CNPC suite on T-34C	• Fly CNPC suite in mixed traffic
IT&E	• Ikhana Flight • ADS-B + FMS • Support FAA demo • Integrate GCS + Sims • Prep for future demos	• Specific objectives for Phase II tests	• HiTL Sim • NextGen NAS • Tactical SA • Nominal UAS Ops • NAS compliant GCS • CNPC protocol and security implementation • Flight Demo • NextGen NAS • Tactical SA • NAS compliant GCS	• Flight Demo • NextGen NAS • Tactical SA • Nominal UAS Ops • NAS compliant GCS • CNPC protocol and security implementation • Cert case study data • 2 UAS / multiple manned A/C	• Flight Demo • NextGen NAS • Tactical SA • Nominal and Off-nominal UAS Ops • NAS compliant GCS • CNPC protocol and security implementation • Cert case study data • 3+ UAS / multiple manned A/C

Integrated Tests and Evaluations

- Partnerships and Leveraging Other Work
  - IT&E inherits partnerships from the subelements.
  - Partnership with FAA provides FAA with build up for their demo, leaves behind capability for future UAS integrated test flights, and allows UAS project an early look at ADS-B operability.
  - Potential for OSD/AFRL Automatic Collision Avoidance Technology (ACAT) cooperation/participation in flight demonstrations
  - ARRA tool and tool interface development
  - ARRA developed surrogate testbed for comm research
  - Potential to leverage FY10 in-guide funding for flight demonstrations

- **Integrated Flight Test 1 (End of Year 1)**: Demonstrate ADS-B and FMS on Ikhana
  - *Rationale*:
    - Build up for FAA demo of ADS-B and FMS on Predator-B.
    - Provide data to SACA related to the performance and accuracies of ADS-B information for UAS applications
    - Provide early integration of Ikhana Ground Control Station (GCS) with Ames and FAA air traffic simulations.
    - Integrate ADS-B on Ikhana for future flights
  - *Approach*: Fly Ikhana equipped with ADS-B in restricted airspace. Use simulated traffic to feed FMS, which will run in parallel with GCS controlling Ikhana. Evaluate FMS performance in a number of simulated traffic scenarios.
  - *Resources:*
    - FAA-provided FMS
    - Ikhana aircraft, GCS and personnel
    - FAA and ARC sims
    - Restricted airspace

1 UAS
Simulated Traffic
20 Flight Hours
Data for FAA, SACA

- **Integrated Sim 1 (End of Year 3)**: Evaluate Tactical SA algorithms during nominal operations using human-in-the-loop simulations
  - *Rationale*:
    - Evaluate performance of tactical SA algorithms
    - Evaluate NAS compliant GCS
    - Evaluate performance of CNPC and security protocols
    - Provide build-up to Integrated Flight Test 2 (next slide)
  - *Approach*: Using simulated UAS "flown" by pilots, simulated mixed traffic (UAS and piloted), and simulated ATC "fly" a number scripted test conditions. NAS-compliant GCS features run in parallel with stations controlling the UAS. Simulated CNPC comm and security protocols in conjunction with tactical SA algorithms to evaluate interaction between comm protocols and SA algorithms.
  - *Resources:*
    - SACA-provided SA algorithms
    - PAI-provided GCS features
    - NASA-provided UAS and manned aircraft simulations
    - Comm-provided CNPC and security protocol sims
    - Air Traffic Control Workstations

Simulated UAS
Simulated Traffic
Simulated ATC
Data for SACA, Comm, PAI

- **Integrated Flight Test 2 (End of Year 3)**: Use two UAS to demonstrate available flight and ground based UAS technologies in preparation for the fully integrated flight demonstration.
  - *Rationale*:
    - Evaluate performance of tactical SA algorithms in relevant environment
    - Evaluate NAS compliant GCS in relevant environment
    - Integrate ADS-B on UAS for future flights
    - Build up to Integrated Flight Test 3 (next slide)
  - *Approach*: Using two ADS-B equipped UAS, fly a number of scripted test conditions. Run the NAS-compliant GCS features in parallel with stations controlling the UAS.
  - *Resources:*
    - SACA-provided SA algorithms
    - PAI-provided GCS features
    - NASA-provided UAS and personnel
    - Restricted airspace

2 UAS
Real UAS Traffic
30 Flight Hours per UAS
Data for SACA, PAI

- **Integrated Flight Test 3 (End of Year 4)**: Demonstrate available flight and ground based UAS technologies to build up to final flight demonstration (Integrated Flight Test 4).

> Specific objectives and details to be developed during phase 1

  - *Rationale*:
      - Evaluate performance of tactical SA algorithms
      - Validate CA requirements
      - Validate NAS compliant GCS
      - Evaluate performance of CNPC and security protocols
      - Provide data for certification case study use

  - *Approach*: Fly multiple UAV systems with multiple piloted aircraft in restricted airspace. The UAS will use features of the prototype NAS compliant Ground Control Station (GCS). One of the manned aircraft will employ the candidate control and non-payload communications (CNPC) protocol and security systems. Both the cockpit and ground personnel will be using the latest Separation Assurance and Collision Avoidance technologies. Nominal and off-nominal air traffic situations will be conducted to exercise the technologies. Simulated air traffic control will be used to evaluate controller workload.

  - *Resources:*
      - NASA-provided manned aircraft
      - NASA-provided UAV systems
      - Air Traffic Control workstations
      - Restricted airspace
      - SAI-provided tactical SA algorithms
      - PAI-provided NAS compliant GCS features
      - Comm-provided CNPC datalink and security systems

> 3 UAS
> 2 manned aircraft
> 30 Flight Hours per aircraft/UAS
> Data for SACA, PAI, Comm

- **Integrated Flight Test 4 (End of Year 5)**: Demonstrate available flight and ground based UAS technologies
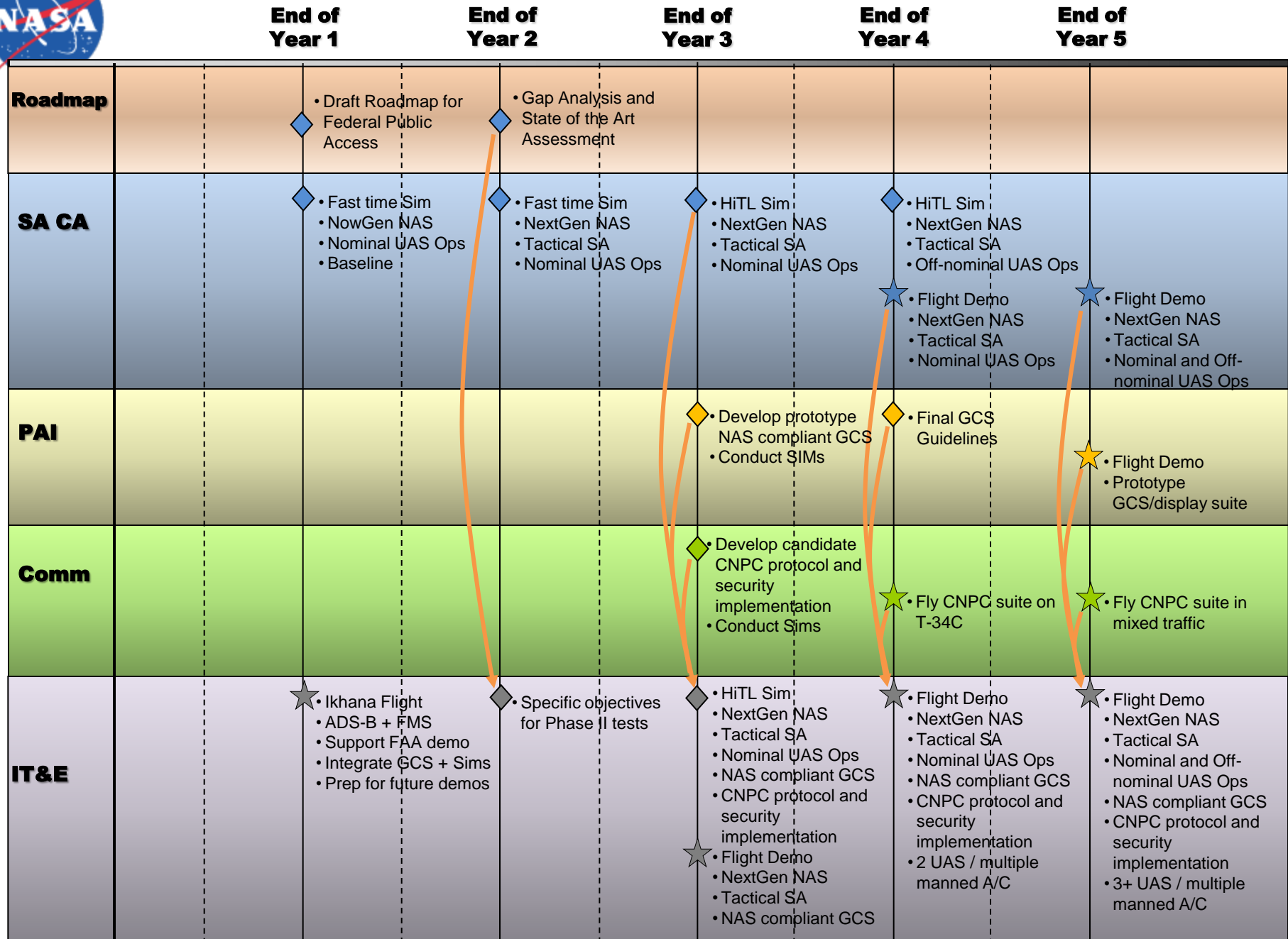
> Specific objectives and details to be developed during phase 1

  - *Rationale*:
    - Evaluate performance of tactical SA algorithms
    - Validate CA requirements
    - Validate NAS compliant GCS
    - Evaluate performance of CNPC and security protocols
    - Provide data for certification case study use

  - *Approach*: Fly multiple UAV systems with multiple piloted aircraft in restricted airspace. The UAS will use features of the prototype NAS compliant Ground Control Station (GCS). One of the manned aircraft will employ the candidate control and non-payload communications (CNPC) protocol and security systems. Both the cockpit and ground personnel will be using the latest Separation Assurance and Collision Avoidance technologies. Nominal and off-nominal air traffic situations will be conducted to exercise the technologies.

  - *Resources:*
    - NASA-provided manned aircraft
    - NASA-provided UAV systems
    - Air Traffic Control workstations
    - Restricted airspace
    - SAI-provided tactical SA algorithms
    - PAI-provided NAS compliant GCS features
    - Comm-provided CNPC datalink and security systems

> 3 UAS
> 1 Surrogate UAS
> 2 manned aircraft
> 30 Flight Hours per aircraft/UAS
> Data for SACA, PAI, Comm

UAS Integration in the NAS IT&E Milestones

	End of Year 1	End of Year 2	End of Year 3	End of Year 4	End of Year 5
Roadmap	• Draft Roadmap for Federal Public Access	• Gap Analysis and State of the Art Assessment			
SA CA	• Fast time Sim • NowGen NAS • Nominal UAS Ops • Baseline	• Fast time Sim • NextGen NAS • Tactical SA • Nominal UAS Ops	• HiTL Sim • NextGen NAS • Tactical SA • Nominal UAS Ops	• HiTL Sim • NextGen NAS • Tactical SA • Off-nominal UAS Ops • Flight Demo • NextGen NAS • Tactical SA • Nominal UAS Ops	• Flight Demo • NextGen NAS • Tactical SA • Nominal and Off-nominal UAS Ops
PAI			• Develop prototype NAS compliant GCS • Conduct SIMs	• Final GCS Guidelines	• Flight Demo • Prototype GCS/display suite
Comm			• Develop candidate CNPC protocol and security implementation • Conduct Sims	• Fly CNPC suite on T-34C	• Fly CNPC suite in mixed traffic
IT&E	• Ikhana Flight • ADS-B + FMS • Support FAA demo • Integrate GCS + Sims • Prep for future demos	• Specific objectives for Phase II tests	• HiTL Sim • NextGen NAS • Tactical SA • Nominal UAS Ops • NAS compliant GCS • CNPC protocol and security implementation • Flight Demo • NextGen NAS • Tactical SA • NAS compliant GCS	• Flight Demo • NextGen NAS • Tactical SA • Nominal UAS Ops • NAS compliant GCS • CNPC protocol and security implementation • 2 UAS / multiple manned A/C	• Flight Demo • NextGen NAS • Tactical SA • Nominal and Off-nominal UAS Ops • NAS compliant GCS • CNPC protocol and security implementation • 3+ UAS / multiple manned A/C

Summary

- NASA has developed a project plan to address issues related to UAS access to the NAS

    - Plan is being formulated with inputs from our stakeholders

- NASA will work with our stakeholders to develop ConOps and a national roadmap to determine key research technologies and policy issues to enable UAS access to the NAS

- NASA will use ConOps and roadmap to either validate current NASA research investment areas and make any necessary changes to proposed UAS research portfolio

- NASA will conduct integration and testing of key research areas to enable UAS access to the NAS